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RS - INT
REGENERATION
Planting
Direct Seeding - 1940

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PROGRESS REPORT

DIRECT SEEDING OF PONDEROSA PINE - 1940

Introduction

The establishment of seedlings on the Direct Seeding plots in 1940 was not as successful as had been hoped for; in fact, on only one plot was there a marked improvement over 1939 results. Protection from rodents was apparently improved on certain plots, but not on others, and the exceptional heat and drought of summer took a heavy toll of seedlings. Soil moisture still seems to be the limiting factor to successful seedling survival in Boise Basin when rodent damage is curbed.

Four plots--Pine Creek South, Pine Creek Draw, Station Area South, and Elk Creek North--yielded sufficient survival to warrant summarizing the results in rather detailed form. Granite Creek Flat, and the three Clear Creek plots produced such low survival and even initial establishment figures they did not justify summarizing. In the following discussions the figures and statements refer only to the four plots intensively analyzed, unless otherwise indicated.

Results of Various Treatments

Screen Cone Protection and Size of Cones

As was stated in the "Supplement to Artificial Seeding Working Plan of October 15, 1938," "Rodents will eat seeds and seedlings in the spring and early summer and may eat them later on, but losses from late July may be

reasonably light and not serious except in localized spots." Considering large cones we find that only 18.3 percent of the "I" spots contained seedlings at the first inspection, whereas 66.3 percent of the deferred removal spots showed initial seedling establishment (table 1).

Table 1.- Spot establishment at time of first inspection.

Large Cones					Small Cones				
Screen*	Fertilizer**	No. Spots Seeded	No. spots with 1 or more live sdlgs. at first inspection	Estab. %	Screen*	Fertilizer**	No. Spots Seeded	No. spots with 1 or more live sdlgs. at first inspection	Estab. %
I	N	60	11	18.3	I	N	60	4	6.7
	M	60	11	18.3		M	60	4	6.7
	N+M	120	22	18.3		N+M	120	8	6.7
DR	N	300	219	73.0	DR	N	240	95	39.6
	M	300	179	59.7		M	240	97	40.4
	N+M	600	398	66.3		N+M	480	192	40.0

* Screen removal - "I" = immediate, i.e., no screen: "DR" = deferred removal, screened part or all year.
** Fertilizer - "N" = none; "M" = manure.

Table 2.- Spot survival at end of first growing season.

Large Cones					Small Cones				
Screen	Fertilizer	No. Spots Seeded	No. spots with 1 or more live sdlgs. at end of first growing season	Sur. %	Screen	Fertilizer	No. Spots Seeded	No. spots with 1 or more live sdlgs. at end of first growing season	Sur. %
I	N	60	1	1.7	I	N	60	1	1.7
	M	60	0	0		M	60	0	0
	N+M	120	1	0.8		N+M	120	1	0.8
J	N	60	10	16.7	J	N	60	1	1.7
	M	60	4	6.7		M	60	1	1.7
	N+M	120	14	11.7		N+M	120	2	1.7
A	N	60	22	36.7	A	N	60	1	1.7
	M	60	0	0		M	60	1	1.7
	N+M	120	22	18.3		N+M	120	2	1.7
F^1,S,F^2	N	180	55	30.6	F^1,S	N	120	7	5.8
	M	180	13	7.2		M	120	11	9.2
	N+M	360	68	18.9		N+M	240	18	7.5
DR	N	300	87	29.0	DR	N	240	9	3.8
	M	300	17	5.7		M	240	13	5.4
	N+M	600	104	17.3		N+M	480	22	4.6

For small cones the corresponding figures are 6.7 percent and 40.0 percent, respectively. Since there apparently should be no difference between large and small cone "I" spots, the difference between the 18.3 percent and 6.7 percent may be accidental or may be due to the fact that a larger number of rodents were attracted to the small cone area. The small cones cannot be set so firmly and are misplaced more by frost heaving than are large cones, hence there is a greater amount of available seed or seedlings for rodent consumption on the smaller cone areas.

At the end of the year the unprotected spots were essentially a complete failure, with an average spot survival of only 0.8 percent, compared to 17.3 percent for large cones and 4.6 percent for small cones (table 2). This difference between large and small screen cones is thus much greater than the corresponding difference in initial establishment, and substantiates previous demonstration of the superiority of the larger size cone.

Time of Cone Removal

Only two sets of cones were removed prior to fall--one set on July 10-11, the other on August 14-15. It had been fairly well established in the 1939 tests that but few seedlings were destroyed by small rodents after August, though some losses occurred on spots where cones were removed in June. The removal in July 1940 was to check further the "safe date" in this respect, and also to determine whether leaving the screens in place to August or to the end of the year would reduce losses from other causes, particularly heat kill.

Although the data are inadequate for statistical analysis, there is strong evidence that keeping the screens on at least until mid-August substantially reduces heat and drought kill (effects of the two factors

could not be distinguished in late summer). Of the unfertilized spots with living seedlings, 57 percent failed by August 15 in rows where large cones were removed in July; only 24 percent failed where cones were left on. A similar relation is shown on the basis of number of individual seedlings: of those present in July, 59 percent died from heat or drought by August 15 where protection was removed; 37 percent died on protected spots. There seems to be less advantage in maintaining screen cover after August. Thus, the spot mortality from August 15 to end of season was 32 percent for rows with cones removed in July and August, compared to 39 percent for rows with cones in place. Heat and drought losses in the same period were 46 percent on unscreened spots and 40 percent on screened spots, on the basis of number of individual living seedlings present on August 15. It is notable that the loss of only 2 seedlings, on 1 spot, was charged to "rodent consumption" on the spots where cones were removed in July and August. Hence, screening to July 10 gave adequate protection against seed-eaters on these plots and in this particular season.

Scalping (Soil Preparation)

As would normally be expected, especially during a dry year, scalping seems to influence seedling survival. Only one plot, Elk Creek North, showed greater survival on no-scalp plots. Scalping apparently did not materially influence germination or "initial spot establishment."

For the large cones, spots with no scalping yielded a 12.5 percent spot survival figure at the end of the season. Averaging spots with small and large scalps, spot survival equals 19.5 percent. Large scalps, with an average survival of 27.5 percent, were in most cases superior to small scalps, with an average survival of 11.5 percent.

Spots with small cones were so affected by rodents as to render a size of scalp comparison worthless. See tables 3 and 4.

Table 3.- Initial spot establishment as regards size of scalp. (Screened spots only.)

Large Cones					Small Cones				
Scalp	Fertilizer	No. Spots Seeded	No. spots with 1 or more live sdlgs. at first inspection	Estab. %	Scalp	Fertilizer	No. Spots Seeded	No. spots with 1 or more live sdlgs. at first inspection	Estab. %
None	N	100	73	73.0	None	N	75	36	48.0
	M	100	54	54.0		M	75	29	38.7
	N+M	200	127	63.5		N+M	150	65	43.3
Small	N	100	77	77.0	Small	N	75	33	44.0
	M	100	64	64.0		M	75	39	52.0
	N+M	200	141	70.5		N+M	150	72	48.0
Large	N	100	69	69.0	Large	N	75	26	34.7
	M	100	61	61.0		M	75	29	38.7
	N+M	200	130	65.0		N+M	150	55	36.7

Table 4.- Spot survival as regards size of scalp. (Screened spots only.)

Large Cones					Small Cones				
Scalp	Fertilizer	No. Spots Seeded	No. spots with 1 or more live seedlings at end of first growing season	Sur. %	Scalp	Fertilizer	No. Spots Seeded	No. spots with 1 or more live seedlings at end of first growing season	Sur. %
None	N	100	25	25.0	None	N	75	4	5.3
	M	100	0	0		M	75	5	6.7
	N+M	200	25	12.5		N+M	150	9	6.0
Small	N	100	20	20.0	Small	N	75	3	4.0
	M	100	3	3.0		M	75	6	8.0
	N+M	200	23	11.5		N+M	150	9	6.0
Large	N	100	42	42.0	Large	N	75	3	4.0
	M	100	13	13.0		M	75	2	2.7
	N+M	200	55	27.5		N+M	150	5	3.3

Fertilizer

The fortified manure seems to have some effect on initial establishment of the seedlings. It is noted in large cone spots that 2,576 seedlings

germinated on nonmanured spots and 1,838 or only 71.4 percent germinated on manured spots. In addition, table 1 shows 73.0 percent spot germination on N spots and only 59.7 percent on M spots. It seems that throughout all the Direct Seeding plots there is some difference; however, it is only on the Elk Creek North plot that the seedling establishment shows a very marked degree of N success over M.

It seems there is a slight tendency for rodents to bother young seedlings in manured spots less than in the nonmanured; this is indicated by the numbers of seedlings recorded as "rodent-consumed" at the date of first inspection.

As regards seedling survival the fortified manure seems to have a bad effect on the young seedling roots (table 2). This effect starts in early summer and continues throughout the dry season. It may be due either to the spongy, dry nature of the manure or to too great a concentration of chemicals around the young roots, or to both. Inspection showed that the fertilizer in most instances was in a mass rather than mixed with soil as well as had been intended, and at midsummer it appeared very dry. Junior Agricultural Aid Melvin, who had worked with fertilizers as his Master's thesis problem, was of the opinion that the concentration was high enough to be injurious. It was observed in some cases that the shallow-rooted annual grasses dried up prematurely on manured spots.

Location

The general results in relation to plot location and aspect are summarized in table 5. As has been mentioned, the Pine Creek North Slope plot, the Granite Creek Flat plot, and all of the Clear Creek plots were

essentially complete failures. Of the unprotected spots on the other plots, one or more seedlings were found early in the year on 20 percent of the spots planted on the Elk Creek plot, but only 1 percent had survivors at the end of the year; the three others had lesser numbers and none surviving. With screen protection, the best initial establishment was on the Pine Creek South Slope plot, where 83 percent of the spots with large cones had seedlings, and 56 percent under small cones. Best survival at the end of the year, however, was on the Pine Creek Draw plot for large cones (34 percent) and on the Elk Creek North plot for small cones (8 percent). Thus the advantage of draw bottom and northerly slope sites is again demonstrated. Although direct comparison was never intended, it is interesting to note the final survival of 10 percent on the Pine Creek South and of 34 percent on the Draw plot, in contrast to the transplant survival of 0.6 percent on the east plot and 6.9 percent on the north plot of the nearby root-pruning series.

Table 5.- General plot averages.

Location & Exposure	Unprotected		Large Cones		Small Cones	
	Spot Estab.	Spot Survival	Spot Estab.	Spot Survival	Spot Estab.	Spot Survival
	Percent	Percent	Percent	Percent	Percent	Percent
Station Area-South	17	0	75	7	46	1
Pine Creek-South	3	0	83	10	56	4
Pine Creek-Draw	10	0	73	34	34	5
Elk Creek-North	20	1	41	18	24	8
Pine Creek-North	f	0	11	5	7	3
Granite Creek-Flat	Establishment negligible					
Clear Creek - All	f	f	4*	**	f	f

* Approximate
** Not checked
f Few or none

The detrimental effect of fertilizer was evident on all plots in similar degree. The relative inferiority of small as compared with large cones was also similar on all plots and aspects. Scalping showed to greatest advantage on the Pine Creek Draw plot, to a lesser degree on the Pine Creek South and Station Area South plots, and of apparently no benefit on the Elk Creek plot.

A Discussion of Cause and Date of Seedling Mortality

The preceding discussions and tabulations deal largely with spot survival, with only a general consideration of the causes of death and mortality by periods. Individual seedling mortality will next be analyzed to show more specifically the important causes of death and their relation to time of year.

During the summer of 1940 the Direct Seeding plots were inspected on five different dates. Beginning May 17 the inspections were made with about one month elapsed time between each, ending with the final inspection October 9. Additional inspections were made of the Station area plot on April 16 and June 21, but those results are incorporated with the next succeeding dates in the discussion to follow.

Large Cones

South exposures. It was found that plots on south exposures suffered more from heat than any other one cause (see table 6). Heat losses did not begin to show up until the June 6 inspection, but even though just starting they were exceeded only by drought losses. By the time of the July 11 inspection heat losses amounted to 98.9 percent of all losses during the June-July period. After July 11 very few losses from this cause occurred. As time passed the seedling stems became tougher and probably more resistant to heat.

Table 6.-Summary of cause of seedling mortality - 1940

Plot	No. Seedlings Germ.	Cause of Death	Total Loss from Cause	Pct. Loss	No. Alive	Pct. Live Seedlings	No. Deaths	Pct. Total Deaths
Large Cones								
Station Area (S)	1,481	H	802	54.2			1,453	55.2
		D	601	40.5				41.4
		I	26	1.8				1.8
		Rc	15	1.0				1.0
		Other	9	0.6	28	1.9		0.6
Elk Creek (N)	392	D	188	48.0			252	74.9
		I	28	7.1				11.0
		Rc	10	2.6				4.0
		Rd	8	2.0				3.1
		Other	18	4.6	140	35.7		7.0
Pine Creek Draw	1,179	D	601	51.0			939	64.0
		Rc	187	15.8				20.0
		I	48	4.1				5.1
		H	35	3.0				3.7
		F	21	1.8				2.2
		Other	47	4.0	240	20.3		5.0
Pine Creek (S)	1,384	H	761	55.0			1,329	57.3
		D	330	23.8				24.8
		Rc	138	10.0				10.4
		I	57	4.1				4.3
		Other	43	3.1	55	4.0		3.2
All	4,436	D	1,720	38.8			3,973	43.3
		H	1,598	36.0				40.2
		Rc	350	7.9				8.8
		I	159	3.6				4.0
		F	21	0.5				0.5
		Rd	8	0.2				0.2
		Other	117	2.6	463	10.4		3.0
Small Cones								
Station Area (S)	443	H	341	77.0			442	77.1
		D	85	19.2				19.2
		Other	16	3.6	1	0.2		3.7
Pine Creek (Draw)	215	D	113	52.5			198	57.1
		I	32	14.9				16.2
		H	20	9.3				10.1
		Rc	9	4.2				4.5
		Other	24	11.2	17	7.9		12.1

Table 6.- Continued.

Plot	No. Seedlings Germ.	Cause of Death	Total Loss from Cause	Pct. Loss	No. Alive	Pct. Live Seedlings	No. Deaths	Pct. Total Deaths
Pine Creek (S)	1,133	Rc	636	56.2			1,128	56.4
		H	271	23.9				24.0
		D	195	17.2				17.3
		I	12	1.1				1.1
		Other	14	1.2	5	0.4		1.2
Elk Creek (N)	43	D	23	53.5			32	71.9
		I	4	9.3				12.5
		Rd	3	7.0				9.4
		Rc	1	2.3				3.1
		Other	1	2.3	11	25.6		3.1
All	1,834	H	632	34.4			1,800	35.1
		D	416	22.7				23.1
		I	48	2.6				2.6
		Rc	646	35.2				35.9
		Rd	3	0.2				0.2
		Other	55	3.0	34	1.9		3.1

H = Heat
D = Drought
I = Insects
F = Fungi
Rc = Consumed by rodents
Rd = Dug out or buried by rodents
Other = Unknown and miscellaneous minor causes

On south exposed plots drought appeared to be second in cause of mortality. On the June 6 inspection drought led all other causes, then on July 11 no deaths from drought were recorded. This apparent anomaly requires some explanation. The great majority of losses credited to drought on June 6 were on fertilized spots and as previously explained the premature drying up of seedlings on these spots was largely due to either the mechanical or chemical effects of the fortified manure. This is discussed further in a later paragraph. Although late May and June were abnormally dry they were also abnormally hot. Temperatures of 90 to 101 degrees were recorded in the latter part of June. Because of these excessive temperatures, it is thought that heat probably was the primary cause of death during this period. However, it is probable that at least a portion of the deaths recorded for July 11 should be charged to drought, but as a 0.78-inch rain had fallen on July 3 the examiner could not distinguish true drought conditions and charged all losses to heat. From July 11 to the end of the season drought losses were the main cause of death.

While heat and drought accounted for by far the greatest number of deaths (about 90 percent), insects and rodents accounted for 8 percent, other causes 2 percent, on south exposure plots. Although there were two south exposed plots and but one draw and one north exposed plot, survival on the south exposure made up only 17.9 percent of the total survival.

Since heat and drought seem to be the chief causes of mortality among seedlings on south exposures, it might be well to distinguish between the two. Heat causes death by scorching the young stem, usually at the ground line. At close inspection the scorch is visible on the stem and when the

seedling dries the stem is especially brittle at that point. Sometimes objects such as dead needles, leaves, bits of wood, or small pebbles if resting against the stem may cause a heat lesion when they absorb heat during a hot day. Usually the root remains limber for some time, depending upon the amount of moisture in the soil.

Drought mortality occurs when soil moisture diminishes to the point at which the seedling roots can no longer compete with cohesive forces holding moisture to the soil particles. Since the roots are unable to absorb moisture they dry out, the seedling dies, and the root becomes brittle.

Although, as has been stated, there is a difference between heat and drought mortality, the two are so closely related that in some cases the difference is not distinguishable. This is particularly true when examinations are at infrequent intervals and the seedling remains are very dry when inspected. In such a case it is well to study current precipitation and temperature records. If mortality occurs during a period when soil moisture seems adequate but soil temperatures are high, heat would be the logical explanation of death. This condition might occur during a hot spring period. If soil temperatures were not excessive during a period of limited precipitation, drought would seem to be the mortality factor.

There are those periods when a combination of heat and drought cause excessive mortality among seedlings. If this condition occurs in the spring, it might be reasoned that because of the tenderness of the young stem heat may kill faster than drought. However, in the summer during a period of combined heat and drought, it may be reasoned that the older stems have

progressively become tougher and may be better able to withstand heat than the roots can withstand drought.

It is not evident in the record whether a given death is positively identified as caused by heat or by drought, or classed so because of "circumstantial evidence" and hence possibly subject to question. Although single specific cases might be questioned, it is believed that the losses for a period or the season as a whole are essentially properly classified and may be relied upon.

North and draw exposures. On the north exposed and draw plots, drought appeared to be the prime mortality factor. Drought accounted for 61.2 percent of all losses on these plots, with rodent consumption and insects causing 16.5 percent and 6.4 percent respectively. Survival on the north exposed plot amounted to 30.2 percent of all the plots. That of the draw plot equaled 51.8 percent.

Small Cones

Results of the small cone plots are similar to those of large cones except that rodents caused greater mortality on spots with small cones. The small cones cannot be set so firmly and are subject to frost heaving more than large cones. On the draw plot, insects caused 16.2 percent of the mortality, this being the greatest loss of that kind on any of the plots.

General: Periodic Losses. Considering all plots and cone sizes and all causes of death together, the losses by periods were as shown in table 7.

Table 7.- Mortality by periods*

Period	Percentage loss based on total seedlings germinated	Proportion of total deaths during season	Percentage loss based on periodic no. seedlings
	Pct.	Pct.	Pct.
April - May	13.5	14.6	17.3
May - June	19.7	21.5	22.8
June- July	37.1	40.3	55.6
July - August	13.9	15.1	46.8
August - October	7.9	8.5	49.8
April - October	92.1	100.0	92.1

* Percentages in this table are based upon the appropriate "Total" (N+M) numbers of seedlings given in table 8.

The usual mortality percentage is shown in the first column. The proportion of total losses for the season occurring in each period is given in the second column. Either of these sets of figures is somewhat misleading as early deaths so severely reduced the numbers living that only a few were left to die later in the season. A somewhat different picture of "seasonal hazard" is presented by the percentages of mortality based upon numbers of living seedlings "available" for loss within each period, as shown in the third column. In the interpretation of any of these general percentages, one should have an appreciation of the way they are derived and of the causes of death and other factors that lie behind them.

General: Relation of losses to fertilizing. It appears that throughout the season the fertilized spots sustained relatively higher losses than nonfertilized spots. It is noted (table 8) that the April - May period is an exception to this statement. However, rodent losses on the nonfertilized spots were exceptionally high during this period and tended to introduce an outside error. From April to October the nonfertilized spots lost 88.3 percent of all seedlings germinated while the fertilized spots lost 97.6 percent.

Table 8.- Summary of periodic losses of seedlings by nonmanured and manured spots.

Period	No. seedlings germinated			No. deaths			No. seedlings living			Percentage of loss based on periodic no. of seedlings		
	N	M	Tot.	N	M	Tot.	N	M	Tot.	N Pct.	M Pct.	Tot. Pct.
April - May	2787	2082	4869	593	251	844	2787	2082	4869	21.3	12.1	17.3
May - June	951	449	1400	296	940	1236	3145	2280	5425	9.4	41.2	22.8
June - July	1	0	1	1326	1002	2328	2850	1340	4190	46.5	74.8	55.6
July - August				672	200	872	1524	338	1862	44.1	59.2	46.8
August -October				415	78	493	852	138	990	48.7	56.5	49.8
April - October	3739	2531	6270	3302	2471	5773	3739	2531	6270	88.3	97.6	92.1

During the periods of heaviest losses, May - July, the difference between losses under the two conditions is greatest. It is noted that the percent of loss rises rapidly to the peak period, June - July, but is slow to drop back, probably because of the large number of drought losses during the summer.

The Failure of Direct Seeding on Certain Plots

It has been mentioned that some of the 1940 Direct Seeding plots were almost total failures. These plots--Granite Flat, Pine Creek North, and the Clear Creek plots--simply did not produce. The same plots were nearly complete failures in 1939. A few comments on them may be in order.

Granite Flat. This plot was first inspected June 6. Very few cases of germination were found. No signs of rodent work were observed at this date, but with such a late examination the evidence may have disappeared. The soil was dry.

A brief history of this plot area indicates that before fire destroyed the residual stand of timber, logging operations had concentrated at the plot site. Probably because of gentle topography and central location the area around the plot had been used as a log landing. Since the fire

this same area, which is privately owned, has been subjected to heavy common use grazing.

Aside from a spring drought condition, which in itself might be the limiting factor, it is reasoned that because of previous harsh use of the area resulting in removal of top soil and organic matter, the water-holding capacity of the soil is so reduced the plot is unable to hold even the limited amount of moisture that may be available. In addition, other detrimental factors attendant to soil dessication may be at work.

Pine Creek North. Poor results on this plot seem to be caused by a series of unfavorable factors. Sloughing dirt may in some cases smother seed or injure seedlings; however, the greatest damage from this source seems to be in loosening and tipping screens, thus allowing rodents easy access to both seed and seedlings. Other cases where the sloughing dirt has partially buried the screens have been observed on this plot.

It is thought that effective rodent control is necessary before results can be expected on this plot. Also, stock restrictions may reduce sloughing dirt and stop trampling.

Clear Creek North, South, and Flat. These plots show the result of heavy rodent damage. Some areas seem to support a strain of super-intelligent rodents. On such areas observations indicate that the vandal neatly burrows under the edge of the screen and consumes both seed and seedlings. Whole rows of this sort of work have been observed.

Conclusions

Tentative conclusions from the results of the study to date may be briefed as follows:

1. Direct seeding of ponderosa pine without protection from rodents has failed so consistently that further tests seem futile.

2. Spot seeding with protection from rodents by means of hardware cloth screen cones has given very promising results in some cases, but because of poor results or failures in other cases its general adoption for administrative or commercial reforestation cannot yet be recommended. To make seeding a practicable venture, not only must devices and techniques be perfected to make rodent protection consistently effective, but also means must be found to hold losses from drought, heat, and other causes to an acceptably low figure. Further research is needed.

3. Of the two sizes of cones tested, the larger (10-inch) have given so much better results than the smaller (5-inch) that their additional cost appears to be justified. Some intermediate size may be found that is satisfactory and less expensive.

4. Some degree of soil preparation ("scalping") is sufficiently beneficial on most areas to warrant expenditure of labor to accomplish it. The present study indicated that fairly large scalps (30 inches wide) were more effective than small ones, but this was not true in the seeding-planting comparison study. The questions of extent and justifiable cost of soil preparation are still unsettled.

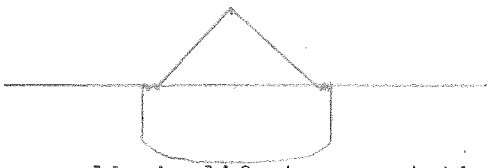
5. Screen cones should be left on the seed spots until at least mid-August of the first year, and preferably until fall. The possible advantage of leaving them in place beyond the first year has not been adequately tested, but it is not likely to be very great.

6. The use of commercial fertilizer and manure in the manner and amounts applied in this experiment is distinctly harmful. The question of fertilizing needs further study and testing before general conclusions can be drawn.

Recommendations for Future Direct Seeding Work

With a reasonable indication as to the factors causing mortality in direct seeding experiments, it is desirable to improve present protective measures and try new schemes, such as the following:

(a) Rodent protection. (1) The cones used to screen against rodents would be more effective if they could be made more stable. A suggested method is to attach a tin cylinder to the base of the cone. The cylinder, 3 or 4 inches deep, could be set into the ground providing protection against burrowing while also giving stability to the cone.



A removable cylinder would simplify transportation problems. An alternative scheme would be the use of a similar cylinder of hardware cloth.

(2) A poisoning program before planting to reduce rodent population.

(b) Heat protection. (1) Shading planted spots by means of cloth or paper attached to cones or spread horizontally over the cone.

(2) Shading spots with shingles stuck in the ground beside the spot or placed horizontally up over the spot.

(3) Increasing shade provided by the screen itself by use of finer mesh (1/4-inch probably the practicable minimum).

(c) Drought protection. (1) Place a layer of heavy paper over the ground to prevent superficial drying of the soil while seedling is becoming established. Make holes for seedlings to come up through.

It was planned to reseed the large-cone spots on the Station Area South, Pine Creek South, Pine Creek Draw, Granite Creek Flat, and possibly the Elk Creek North plots in the fall of 1940. Where 1939 or 1940 seedlings are present the new planting would be made alongside. Scalps would be the same as before, freshened where necessary. No new fertilizer would be applied, but the old would be dug up and worked more thoroughly through the top four or five inches of soil; thus a measure of second-year fertilizer effects would be obtained. All screen cones would be left on until the first fall (or some longer), but if sufficient seedlings appeared a schedule of thinnings of seedlings would be applied instead of the varied dates of screen removal. This procedure is a compromise between the ideal of initiating a full revision of the study and suspending it entirely, necessitated by the lack of time and personnel for the former. It might at least give some measure of results in a different season than the "tough" ones of 1939 and 1940. Because of snow and freezing weather throughout November it was possible to plant only the Station Area South plot per this plan. If it should be possible to get on the ground early enough in the spring of 1941, the balance of the seeding might be attempted then, although results of spring seeding so far have not been at all encouraging.

It does not seem worthwhile to continue work on the Clear Creek area, much as one dislikes to withdraw from such an unsolved problem area. This is private land not under our control, and grazing is excessive. The advantage of planting on a fresh burn, which was the principal factor in the choice of the area in 1938, no longer holds. It also seems

desirable to discontinue efforts on the Pine Creek North plot, which is on State land, and thus subject to both sheep and cattle grazing; it may be that direct seeding cannot be used on such steep slopes in a soil that sloughs excessively.

Other suggestions for future work, relating largely to the techniques and variables already tested, are as follows: (1) The use of fertilizer to give the seedlings a "quick start" should be considered as still having possibilities and should be tested further, with proper modification of the quantity and technique applied in 1940. This is of somewhat lower priority than other tests, but might be incorporated in further experiments without entailing much additional work. (2) On the basis of results here as well as in the competition study, it still appears that larger areas of soil preparation should be advantageous in places where vegetation is heavy. (3) Possibly a follow-up of initial scalping by weeding should be tested. (4) The thinning of seedlings in spots should certainly be given a systematic trial. (5) The reduction of the number of seed planted may also be in order. (6) The use of an intermediate size screen cone, say with an 8-inch base, should be given a comparative test. This is more in the line of cost-reduction than of obtaining greater survival, however, and could be deferred until later, perhaps when large-scale seeding is adopted. (7) The seeding of unprotected spots in future tests should be made only in new locations where it is desired to get an idea of rodent activity and even there on a limited scale. It is possible that extensive, unprotected seeding merely attracts rodents to the area and leads them to search out and consume seed under the screens as well. (8) As a general suggestion for any further direct seeding

experiments, there should be ample provision for closer follow-up, that is, more frequent inspections, especially early in the season. Once a month is not too often in tests such as those of 1939 and 1940.

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(Added to and amended by
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Reviewed by Director Bailey, March 1941
Copy given him for traveling file.